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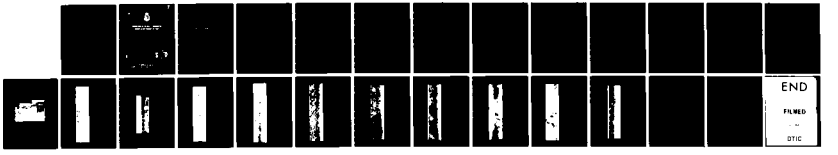

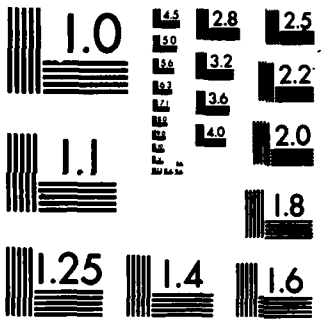

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AD-A145 970

PRODUCTION OF OPTICALLY CORRELATED SEASAT-A SAR IMAGERY AT DREO

by

N. Brousseau and J.W.A. Salt

DEFENCE RESEARCH ESTABLISHMENT OTTAWA
TECHNICAL NOTE 82-19

Canada

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ABSTRACT

Examples of optically correlated imagery from the SEASAT-A Synthetic Aperture Radar are presented. A list of the imagery produced at DREO is included.

RÉSUMÉ

On présente des exemples d'imagerie corrélée optiquement à partir des interférogrammes de radar à antenne synthétique du satellite SEASAT-A. Une liste de l'imagerie produite au CRDO est incluse.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ACRONYMS

APS	:	Applied Physics Specialties
CIR	:	Canadian Instrumentation and Research Ltd., Mississauga
CRC	:	Communications Research Centre (Shirleys Bay)
CRDO	:	Centre de Recherche pour la Défense, Ottawa
DND	:	Department of National Defence
DREO	:	Defence Research Establishment Ottawa (Shirleys Bay)
DREP	:	Defence Research Establishment Pacific (Victoria)
ERIM	:	Environmental Research Institute of Michigan
NWT	:	North West Territories
SAR	:	Synthetic Aperture Radar
SEASAT:		SEA SATellite
SURSAT:		SURveillance SATellite

ACKNOWLEDGEMENTS

We would like to express our gratitude to the personnel in the Remote Sensing Section of Electronics Division, especially to Mr. Francois Paquet for making repairs to the electronic control system operating the film drives. We would like also to acknowledge the invaluable help of Dr. B. Young on many of the mechanical problems that had to be solved to make the correlator operational. Dr. Young's and Ms. D. Desaulniers' contributions to the interpretation and the localization of the imagery were most appreciated. Finally, we would like to acknowledge the contribution of Mr. T. Froelich, on loan from CCRS for a period of three months, during the last stages of debugging the optical correlator.

INTRODUCTION

The work on optical processing of Synthetic Aperture Radar (SAR) interferograms started at DREO in 1974 with the publication by R.T. Lowry (1) of a feasibility study and the building of a prototype made of low quality spherical and cylindrical lenses from Edmund Scientific Inc.

Contracts were later issued to Canadian Instrumentation and Research Ltd. (CIR) to design a static correlator able to process

1) the X- and L-band SAR interferograms from Environmental Research Institute of Michigan (ERIM) and
2) the X-band SAR produced by Communications Research Centre (CRC) developmental SAR system.

Applied Physics Specialties (APS) manufactured the optical components that were specified by the CIR design. The correlator was designed to produce maximum resolution images over a large field of view (25km x 5km) in order to provide sufficient instant area display on a television monitor. This correlator was not aimed at the recording of imagery on film, therefore the precision film drives needed to make film recording in a tracking mode were not incorporated into this system. More details on the parameters and the operation of that correlator can be found in references 2, 3 and 4.

Later DND decided to participate in the SEASAT project. In March 1977 DREO's contribution was requested by the SURSAT office to supply correlated SEASAT imagery to the user community. A new correlator adapted to the SEASAT SAR parameters was designed and manufactured by CIR and APS, the same contractors that produced the first correlator, under the contract signed in June 1978. This design was based on studies made by CRC and DREO on optical correlation of SEASAT-A data (5-8). The system proposed was to be a film production unit, thus requiring controlled and synchronized input interferogram film drive with liquid gate unit and a film recording camera. The range curvature correction system was designed from data developed from a theoretical study on range curvature aberration made at DREO (9).

The SEASAT SAR correlator delivered to DREO in May 1979 was used to process all the good interferograms available from the DREO 'Back-up' optical film recorder (6,7) and the new DREO optical film recorder (8). Imagery from 13 different orbits of the satellite was produced of survey quality or better. A total of about 2,700,000 square kilometers of survey quality imagery was delivered to the SURSAT Office. The list of the imagery produced by the SEASAT optical correlator at DREO can be found in Table 1.

TABLE 1

List of the Imagery Optically Correlated at DREO

Orbit	Optical Recorder	Swath Processed	Location
472	back-up	1;2	Guatemala, Gulf of Mexico, USA, Ottawa
474	back-up	1;2	Vancouver, Victoria
716	back-up	1;2	Northern Labrador, Quebec, Lake Ontario
762	back-up	1;2	Greenland, Iceland, East shore of England France, Corsica, Sardinia
780	back-up	1;2;3;4	Coronation Gulf, Arctic Ocean
793	back-up	1;2	Coast of Labrador, Newfoundland
888	back-up	1;2	Maine, New Brunswick St. Lawrence, Quebec
1361	back-up	1;2	Maine, New Brunswick St. Lawrence, Quebec
1395	back-up	1;2	Baffin Island
1404	back-up	1;2	Maine, New Brunswick St. Lawrence, Quebec
1438	back-up	1;2	Baffin Island
1447	back-up	1;2	Maine, New Brunswick St. Lawrence, Quebec
1490	back-up	1;2	Maine, New Brunswick St. Lawrence, Quebec

PRODUCTION OF OPTICALLY CORRELATED SEASAT-A SAR IMAGERY AT DREO

The DREO optical correlator for SEASAT-A SAR data was of the tilted plane type (Fig. 1). It was assembled with separate spherical and cylindrical lenses with exception of the range curvature correction assembly. This consisted of four sphero-cylindrical lenses. The adjustments required to correct for the range curvature aberration of the data were made by rotating two of the lenses and tilting the two others. The system was designed to record imagery on film.

The resolution of the imagery produced by the correlator was measured and found to be 40m in range and 80m in azimuth. These measurements were made by using the same techniques as proposed by ERIM (10). This involved choosing a point reflector having enough returned energy to obtain visible sidelobes in the image. The distance between the sidelobes was measured and the resolution was deduced (11) from this data, taking into account the scaling factor of the imagery recorded on film.

The correlator was used mainly to produce survey quality imagery from the interferograms recorded by the DREO 'Back-up' recorder. Table 1 contains the list of the imagery that was produced and sent to the SURSAT office.

Some examples of the imagery are shown in figures 2 to 11. The prints were produced by contact printing the original imagery produced by the correlator camera. A SAR image from the orbit 474 is shown in Figure 2. One can notice the presence of the HMCS Endeavour, a 70m DREP research ship, and the wakes of several ferries near Vancouver harbour and underway between Vancouver and Victoria. The cities of Vancouver and Victoria are visible. Figures 3, 4, 5, 6 and 7 show SAR imagery from orbit 472. It is part of a 10 minute pass, over 4000 km long, starting in the Pacific Ocean, proceeding NNE, traversing Guatemala, Yucatan, Gulf of Mexico, the Eastern part of the U.S.A., Lake Ontario, Ottawa and finishing in the Gatineau Hills (Québec). It required 10 minutes of correlator time to produce the imagery for that particular orbit and it is, indeed, a good illustration of the enormous quantity of information that an optical correlator can produce at near real time (approximately one hour after satellite transmission). Figures 8 and 9 are from the orbit 1447. Interesting weather features can be seen on the St. Lawrence River surface in Figure 9. Figures 10 and 11 are from the orbit 780 and show the Coronation Gulf area (NWT). Land features and the transition from ice free water to completely ice covered water are visible.

An attempt was made to produce imagery from an ERIM SEASAT interferogram. Unfortunately, the parameters of the interferograms were sufficiently different from the DREO interferograms to make the correlation impossible with our correlator.

CONCLUSIONS

Firstly, the result of the participation of DND in the SURSAT project was the production of optically correlated survey imagery from the SEASAT-A SAR. A considerable amount of imagery was produced (nearly three million square kilometers of the earth's surface) at reasonable cost and relatively high speed by equipment that was designed and manufactured in Canada.

Secondly, the usefulness of the SEASAT-A SAR imagery to DND was evaluated and the experience that was gained through the testing and operation of the correlator as well as in the evaluation of satellite SAR imagery will be invaluable for future SAR related projects.

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Figure 1. The DREO optical correlator for the SEASAT-A SAR data

Figure 2. The Vancouver-Victoria area (orbit 474). SAR Imagery
1) The Endeavour (70m research ship)
2) Fraser River
3) Saturna Island
4) Victoria
5) Strait of Juan de Fuca
6) Lake Crescent
7) Ferries

Figure 3. Standing waves in the Pacific Ocean, West of Guatemala (orbit 472). SAR Imagery

range scale 1:820,000

azimuthal scale 1:820,000

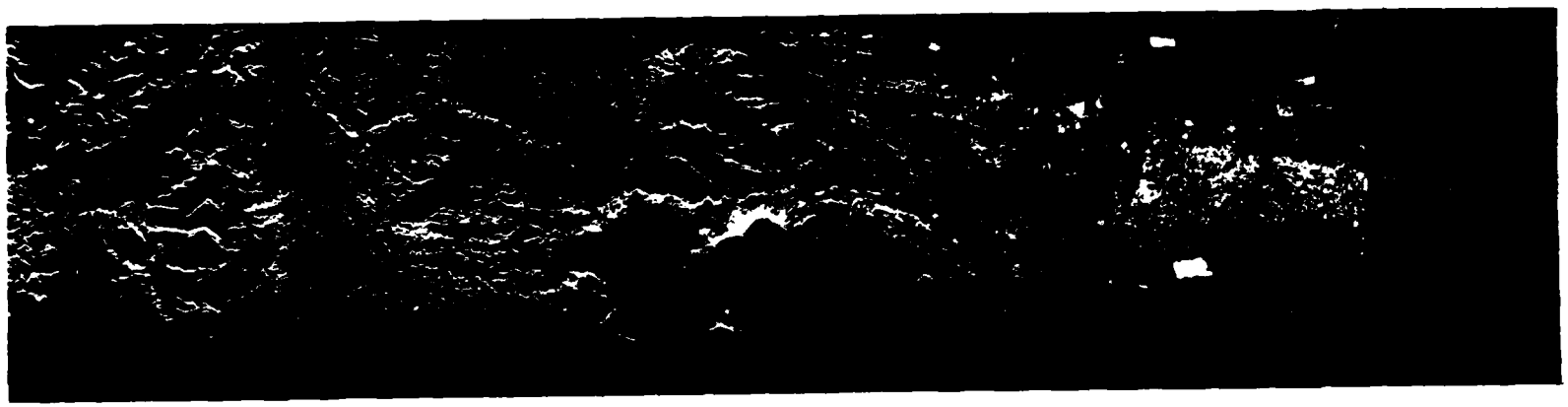

Figure 4. West coast of Guatemala (orbit 472). SAR Imagery

1) Lake Atitlan
2) Volcano (12,000 ft.)
3) West coast of Guatemala
range scale 1:820,000
azimuthal scale 1:820,000

Figure 5. Mexico-Gautemala border (orbit 472). SAR Imagery

1) Oxbow lakes
2) Salinas (Chixoy) River
3) Yucatan (Province of Mexico
range scale 1:820,000
azimuthal scale 1:820,000

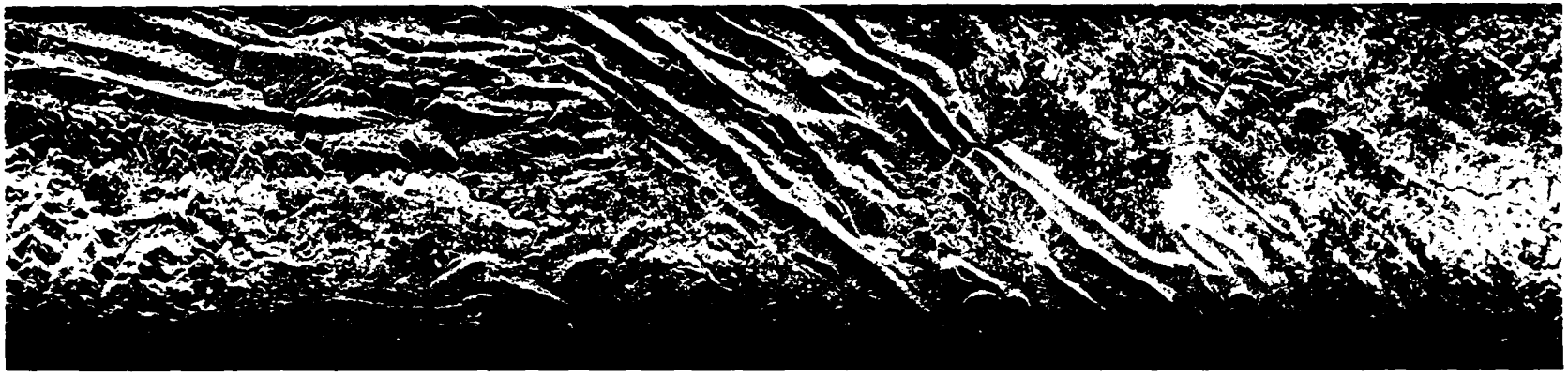

Figure 6. Allegheny Mountain (orbit 472). SAR Imagery

range scale 1:820,000
azimuthal scale 1:820,000

Figure 7. The Ottawa-Hull area (orbit 472). SAR Imagery

1) Lake la Blanche
2) Gatineau River
3) Lake Deschênes
4) Rideau River
range scale 1:820,000
azimuthal scale 1:820,000

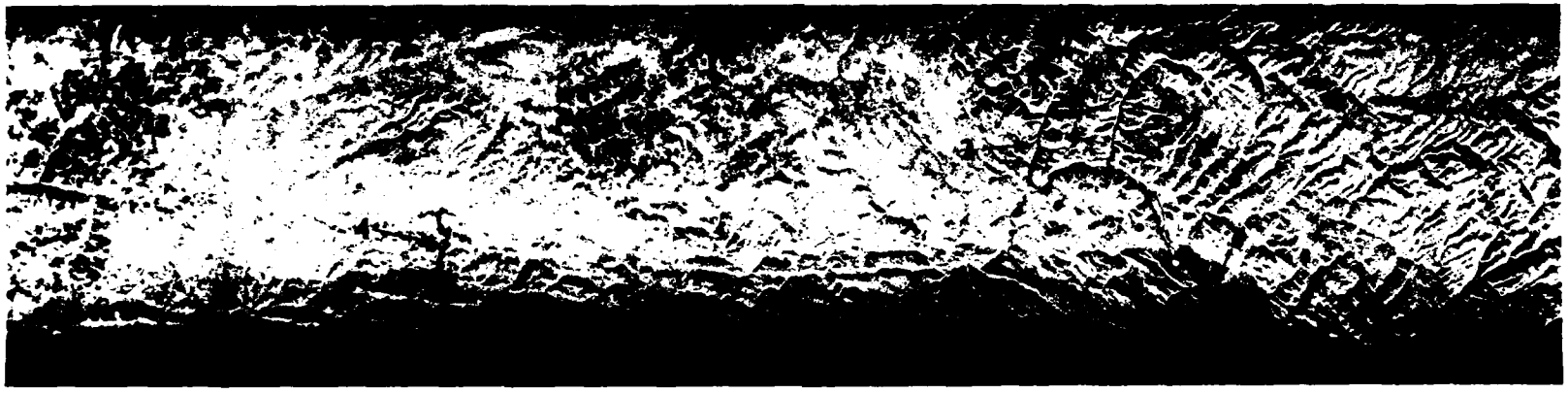

Figure 8. Baie des Chaleurs area, Gaspé (orbit 1447). SAR Imagery

1) Baie des Chaleurs
2) Matapédia River
3) Cross point
4) Sisson Branch Reservoir
range scale 1:820,000
azimuthal scale 1:820,000

Figure 9. Weather features on the surface of the St. Lawrence River (orbit 1447). SAR Imagery

range scale 1:820,000
azimuthal scale 1:820,000

Figure 10. The Coronation Gulf area, NWT (orbit 780). SAR Imagery

1) Klengenberg Bay
2) Basil Bay
3) Berens Islands
4) Lawford Islands
5) Eokuk Lake
range scale 1:820,000
azimuthal scale 1:770,000

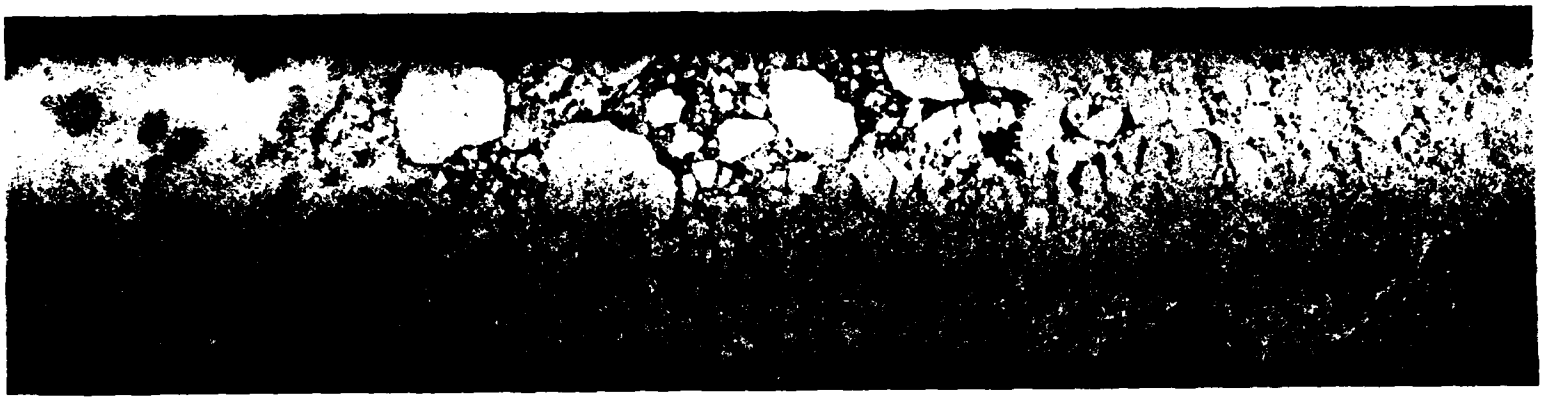

Figure 11. Ice in the Coronation Gulf area, NWT (orbit 780).
SAR Imagery. Ice free water is at the right of the picture.

range scale 1:820,000
azimuthal scale 1:770,000

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